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Shoulder dislocations among high school–aged and college-aged athletes in the United States: an epidemiologic analysis



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Hypothesis/Background: Shoulder dislocations are common orthopedic injuries due to the mobile nature of the glenohumeral joint. High school and collegiate athletes are at particularly high risk for sustaining a dislocation event. Despite the prevalence of these injuries, there is a paucity in the literature regarding incidence of sports-related shoulder dislocations and mechanism of injury within these populations. Therefore, the aim of the present study was to (1) determine the incidence rate of shoulder dislocations in high school–aged and collegiate–aged athletes presenting to emergency departments (EDs) in the United States; (2) to determine the most common sports associated with shoulder dislocations; and (3) to compare the current rates and risk factors for shoulder dislocation with previous trends.

Methods: The National Electronic Injury Surveillance System is a statistically validated injury surveillance system that collects data from ED visits as a representative probability sample of hospitals in the United States. We queried the National Electronic Injury Surveillance System for the years 2015–2019 to examine the following variables for sports-related shoulder dislocations: patient age (high school = 13–17 years of age; collegiate = 18–23 years of age), sex, year of admission, and sport type. Using a weighted multiplier, annual incidence rates were estimated based on the US Census estimates and injury rates were compared by sex and age group across the study period.

Results: From 2015 to 2019, there were a total of 1329 athletic-related shoulder dislocations that presented to participating EDs. Of these, 698 (52.5%) shoulder dislocations occurred in collegiate athletes, while 631 (47.5%) occurred in high school athletes. Using weighted and adjusted estimates automatically generated by the National Electronic Injury Surveillance System database, this translates to 89,511 total athletic-related shoulder dislocations across the United States (95% confidence interval lower bound 68,224; 95% confidence interval upper bound 110,798). Male athletes demonstrated a higher proportion of shoulder dislocations (87%) than female athletes (13%). The most common sport-specific mechanisms of traumatic shoulder dislocation were basketball (24.1%), football (21%), soccer (7.1%), baseball (7.1%), and weightlifting (3.3%).

Conclusion: Sports-related shoulder dislocations are frequent in high school–aged and college-aged athletes presenting to the ED. Interventions to reduce incidence of injury should be sport-specific and focus on those participating in contact and noncontact sports. Male athletes have disproportionately higher rates of dislocation. These findings are consistent with the previous epidemiologic trends in the literature that have examined the incidence of shoulder dislocations in this population.

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Participation in youth athletics in the United States has continued to rise across all sports over the last several decades.²⁰ This has contributed to a direct increase in both high school and

collegiate athletic participation, with an estimate of 7,937,491 high school athletes¹ and 499,217 collegiate athletes nationwide⁷ in the most recent data available for the 2018–2019 season. As involvement in athletics across age groups continues to rise, a proportionate increase in the incidence of upper extremity sports-related injuries is to be expected.

Previous studies have reported that shoulder dislocations are among the most common upper extremity injuries in athletics.^{9,15,21} Furthermore, glenohumeral dislocations account

Institutional review board approval was not required for this retrospective study.
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for 50% of all large joint dislocations in the United States.^{16–18,21} Unfortunately, there is limited epidemiologic data regarding the population incidence of shoulder dislocations and their relationship to sport-specific activities. A recent study reported an incidence rate of .12 glenohumeral instability injuries per 1000 college athlete exposures and found that men were more likely to get injured and that football had the greatest injury rate.¹⁴ Despite the prevalence and substantial amount of literature regarding prognosis and treatment options, the epidemiology of sports-related shoulder dislocations lacks evidence. Furthermore, the sport-specific mechanisms of shoulder dislocation have not been fully elucidated. Assessing the demographic risks and incidence trends is important for developing effective injury-prevention protocols.

While other studies have traditionally examined sport-specific cohorts,^{6,11} general upper extremity injuries,^{10,14} or nonathletic-related traumatic shoulder dislocations,²¹ we sought to examine and compare the total incidence of shoulder dislocations among high school–aged and collegiate–aged athletes across all sports over the last 5 years (2015–2019). Specifically, the aims of the present study were to (1) determine the incidence rate of shoulder dislocations in high school–aged and collegiate–aged athletes presenting to the emergency department (ED) in the United States; (2) to determine the most common sports associated with dislocations; and (3) to compare the recent rates and demographic risk factors for shoulder dislocations to previous trends in the literature.

Materials and methods

Study design

This retrospective cross-sectional descriptive epidemiologic study was determined to be exempt from institutional review board approval. Data were obtained using the US Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS). The NEISS is a randomized, statistically validated injury surveillance system that collects data from ED visits as a representative probability sample of all hospitals in the United States. This sample, which includes patient demographics, can then be used to calculate a weighted estimate of the total incidence of specific injuries associated with specific "consumer product codes." These codes are assigned to each patient and designate the activity engaged in at the time of injury. This allows the NEISS to generate a statistically valid and reproducible epidemiologic database. This database has been used previously to generate epidemiologic injury patterns for many common orthopedic conditions.^{9,11,13,15,19,21}

NEISS database and variables

We queried the NEISS for all cases of shoulder dislocations with a sports-related product code for high school–aged (13–17 years of age) and college–aged (18–23 years of age) athletes for the years 2015–2019. This five-year span represents the most recent longitudinal data available from the NEISS database. To ensure reliability, we reviewed the chief complaint/narrative to ensure the injury was indeed sustained during athletic participation. We excluded any patients who did not present with sports-related injuries and those who had any associated secondary injury (ie, dislocation and a fracture). Following our stratification, the NEISS database yielded 1329 sports-related shoulder dislocations for high school–aged and college–aged athletes from 2015–2019.

We analyzed the descriptive data available for the 1329 cases using the following variables: age group (high school vs. collegiate), sex (male vs. female), time (intervals by one year from 2015–2019)

and sport-specific mechanism (specific consumer product codes). These data were used for both raw calculations (n) and estimated weighted and adjusted injury counts (N) that were automatically generated by the NEISS database using built-in algorithmic software with 95% confidence intervals (CIs) for the entire population.

Statistical analysis

For all national estimates of incidence, upper and lower bounds of a 95% CI were calculated around the weighted estimate by the NEISS query database using the given coefficient of variation and national estimate. United States Census Bureau population estimates and NEISS weighted estimates were used to calculate overall incidence rate per 100,000 at-risk persons in the United States for all shoulder dislocations (high school and collegiate) from 2015 to 2019. In addition, individual incidence rates were calculated per 100,000 at-risk persons in the United States for all shoulder dislocations per year intervals. For all incidence rates calculated, we include 95% CIs. Appropriate odds ratios (ORs) with 95% CI were also calculated for comparative risk estimation between age groups and sex variables. We performed all descriptive statistical analyses using IBM SPSS Statistics (Mac v 27.0; IBM Corp., Armonk, NY, USA). For all contingency table comparisons of categorical variables (ie, age groups vs. sex distributions), we used either chi-square or Fisher's exact tests as appropriate. Statistical significance was set at $P \leq .05$ a priori.

Results

From 2015 to 2019, the NEISS participating EDs recorded 1329 total high school–aged and college–aged patients who presented with athletic-related shoulder dislocations, which translated to a national estimate of 89,511 total sports-related dislocations in the United States. This represents approximately 17,903 shoulder dislocations per-year among athletes aged 13–23 years of age. Using the US Census Bureau population estimates, these data result in a calculated shoulder dislocation per-year incidence rate of 38.19 per 100,000 persons at risk (defined as the average population of 13–23 year of age from 2015–2019). Moreover, there was a five-year overall incidence rate of 190.95 shoulder dislocations per 100,000 persons at risk (95% CI, 144.28 to 234.3) in the United States from 2015 to 2019 (Table 1).

Of the 1329 raw injuries coded in the NEISS, 698 (52.5%) of these shoulder dislocations occurred in college–aged athletes, while 631 (47.5%) occurred in high school–aged athletes. There was no significant difference between incidence of dislocation between high school–aged and college–aged athletes ($P > .05$). However, there was a significant association between sex and age group ($P < .05$). Shoulder dislocations were disproportionately more common in male athletes, with this cohort representing 87.0% ($n = 1156$) of all sports-related shoulder dislocations compared with female athletes (13.0%, $n = 173$) regardless of age group ($P < .05$). (Tables II and III)

From 2015 to 2019, the total incidence of athletic-related shoulder dislocations slightly decreased from 41.34 to 36.3 per 100,000 persons. On a per year basis, the number of dislocations among high school–aged vs. college–aged athletes was not statistically different ($P < .05$) for any year, though both groups did display a trend of incremental decreases in total dislocations per year from 2015 to 2019 (Fig. 1).

In the high school cohort, male athletes accounted for a larger proportion of shoulder dislocations compared with female athletes (81.9% male vs. 18.1% female; $P < .0001$), representing a male-to-female injury proportion ratio of 4.5:1 (Fig. 2). Similarly, college–aged men accounted for a larger proportion of shoulder

Table I
Summary of NEISS shoulder dislocation data overall.

| Year | Raw number of injuries (n) | National weighted estimate (N) | Population estimate (ages 13-23 yr) | I.R. | Lower bound (95% C.I.) (N) | Upper bound (95% C.I.) (N) |
|-------|----------------------------|--------------------------------|-------------------------------------|--------|----------------------------|----------------------------|
| 2015 | 289 | 19,548 | 47,285,512 | 41.34 | 13,947 | 25,149 |
| 2016 | 261 | 18,616 | 47,008,373 | 39.6 | 12,807 | 24,425 |
| 2017 | 278 | 17,789 | 46,839,676 | 37.98 | 14,543 | 21,034 |
| 2018 | 263 | 17,261 | 46,671,955 | 36.98 | 12,915 | 21,606 |
| 2019 | 238 | 16,910 | 46,582,672 | 36.3 | 12,852 | 20,968 |
| Total | 1329 | 89,511 | - | 190.95 | 68,224 | 110,798 |
| | | | | | I.R. | 234.3 |

(n) represents raw number of injuries coded by NEISS; (N) represents the weighted national estimate of injuries; I.R., Incidence rate per 100,000 persons at risk.

Table II
Shoulder dislocations by sex and age group.

| Variable | n | % | P value |
|------------------|------|------|---------|
| Sex | | | <.0001 |
| Male | 1156 | 87.0 | |
| Female | 173 | 13.0 | |
| Age group | | | .066 |
| High school-aged | 631 | 47.5 | |
| College-aged | 698 | 52.5 | |

Table III
Shoulder dislocations per year by sex and age.

| Sex | Year | High school (n) | Collegiate (n) | Total |
|--------|-------|-----------------|----------------|-------|
| Male | 2015 | 113 | 139 | 252 |
| | 2016 | 98 | 126 | 224 |
| | 2017 | 102 | 136 | 238 |
| | 2018 | 105 | 127 | 232 |
| | 2019 | 99 | 111 | 210 |
| | Total | 517 | 639 | 1156 |
| Female | 2015 | 25 | 12 | 37 |
| | 2016 | 24 | 13 | 37 |
| | 2017 | 27 | 13 | 40 |
| | 2018 | 22 | 9 | 31 |
| | 2019 | 16 | 12 | 28 |
| | Total | 114 | 59 | 173 |
| Total | 2015 | 138 | 151 | 289 |
| | 2016 | 122 | 139 | 261 |
| | 2017 | 129 | 149 | 278 |
| | 2018 | 127 | 136 | 263 |
| | 2019 | 115 | 123 | 238 |
| | Total | 631 | 698 | 1329 |

dislocations compared with female athletes (91.5% male vs. 8.5% female; $P < .0001$), representing a male-to-female injury proportion ratio of 10.8:1. In terms of risk estimate, female athletes had increased odds of injury (OR = 2.137, [95% CI: 1.591, 2.872]) at the high school level vs. collegiate level, while male athletes had decreased odds of injury (OR = .895, [95% CI: .857, .934]) at the high school vs. collegiate level. At the collegiate level, male athletes had higher odds (OR = 1.621, [95% CI: 1.309, 2.007]) of injury than female athletes. At the high school level, male athletes had lower odds of injury (OR = .679, [95% CI: .599, .769]) than female athletes. Therefore, male athletes were more likely to have a dislocation at the college level, while female athletes were more likely to have a dislocation at the high school level.

Overall, the most common sports involved in traumatic shoulder dislocation were basketball (24.1%), football (21%), soccer (7.1%), baseball (7.1%), and weightlifting (3.3%) (Table IV). High school athletes participating in football, wrestling, ice hockey, roller hockey, and lacrosse sustained a greater proportion of the sport-specific dislocation events than their collegiate counterparts (Table IV). For the remainder of the reported sports, college-aged athletes sustained a higher proportion of dislocation events.

Discussion

The purpose of this study was to evaluate data from the NEISS database to characterize the sport-specific incidence and demographic risks for sports-related shoulder dislocations among high school-aged and college-aged athletes presenting to US EDs from 2015 to 2019. This study is the first to specifically characterize sports-related dislocations requiring ED evaluation between these age groups.

The most significant findings of this study are that sports-related dislocations disproportionately affect male athletes regardless of age and that basketball and football represent the two most common sports involved in dislocation for high school-aged and college-aged athletes. Furthermore, the NEISS estimated a total of 89,511 athletic-related shoulder dislocations from 2015 to 2019, translating to an incidence rate of 38.19 per 100,000 persons at risk in high school-aged and college-aged populations. While existing relevant epidemiologic data are sparse in the literature, our findings are similar to those of Owens et al¹⁴ who reported an incidence rate for glenohumeral instability of 12 per 100,000 AEs. However, their study examined only collegiate athletes which accounts for our higher overall incidence. Collectively, our data are aligned with the recent epidemiologic trends in the literature regarding sports-related shoulder dislocations that report a higher overall incidence

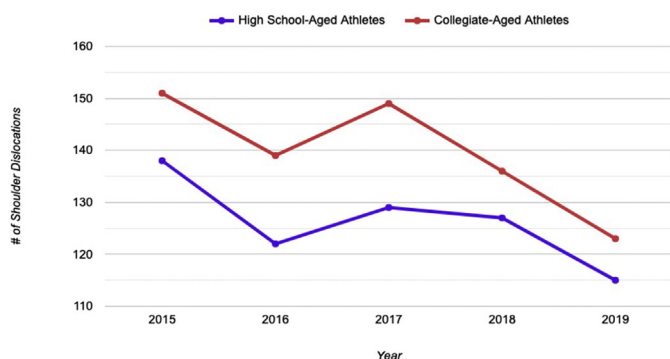


Figure 1 High school-aged vs. college-aged athlete dislocation trends (2015-2019).

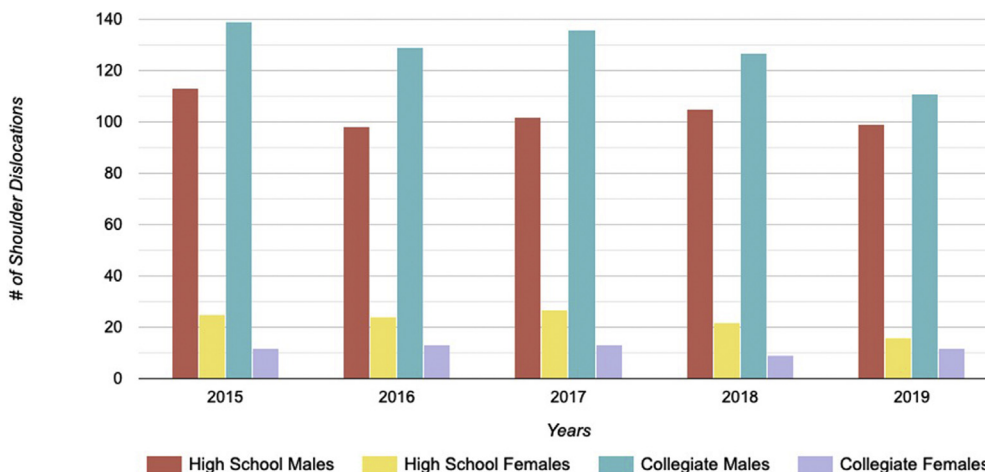


Figure 2 Total occurrence of shoulder dislocations by age and sex from 2015-2019.

Table IV

Most common sports-related shoulder dislocations (2015-2019).

| Rank | Sport | % of total injuries | High school injuries (%) | Collegiate injuries (%) |
|------|---------------|---------------------|--------------------------|-------------------------|
| 1 | Basketball | 24.10 | 10.20 | 13.90 |
| 2 | Football | 21.00 | 15.10 | 5.90 |
| 3 | Soccer | 7.10 | 2.90 | 4.20 |
| 4 | Baseball | 4.40 | 2.20 | 2.30 |
| 5 | Weightlifting | 3.30 | 0.50 | 2.80 |
| 6 | Swimming | 2.90 | 0.70 | 2.30 |
| 7 | Volleyball | 2.90 | 1.40 | 1.50 |
| 8 | Ice hockey | 2.70 | 1.60 | 1.10 |
| 9 | Wrestling | 2.50 | 2.10 | 0.40 |
| 10 | Softball | 2.20 | 1.10 | 1.10 |
| 11 | Boxing | 2.00 | 0.70 | 1.30 |
| 12 | Roller hockey | 1.70 | 1.10 | 0.60 |
| 13 | Snowboarding | 1.70 | 0.40 | 1.30 |
| 14 | Snow skiing | 0.90 | 0.20 | 0.80 |
| 15 | Lacrosse | 0.80 | 0.50 | 0.40 |

of injury among male athletes and among those participating in high-contact/collision sports.^{9,15,19,21}

The present study identified a significantly higher proportion of sports-related shoulder dislocations in the male athletes relative to female athletes (6.7:1 male-to-female ratio). This trend was also observed within the specific high school-aged and college-aged cohorts. In a similar study, Owens et al¹⁴ examined the NCAA Injury Surveillance System to analyze glenohumeral instability trends in collegiate athletics from 1989 to 2004 and found a strong male injury bias. Zacchilli and Owens²¹ also reported that male athletes had a significantly higher proportion of sports-related shoulder dislocations than female athletes. While this trend has been reported by several other groups studying sports-related dislocations,^{8,15,19,21} our study presents the highest magnitude in difference between sexes. One explanation for this finding is that we were unable to control for first-time traumatic vs. recurrent dislocations because male athletes have been shown to be over three times (OR 3.18) more at risk for the latter.¹² In addition, variability in muscle mass, ligamentous laxity, and joint biomechanics between male and female athletes has also been proposed to explain sex differences in shoulder dislocation,⁵ presumably putting male athletes at a higher risk for injury.

Another important finding from the present study was the most common sport-specific causes of shoulder dislocation (Table IV). Overall, from 2015 to 2019, shoulder dislocations were most common in basketball (24.10% of dislocations), football (21.00%), soccer

(7.10%), baseball (4.40%), and weightlifting (3.3%) for high school-aged and college-aged athletes. Interestingly however, for football, wrestling, ice hockey, and lacrosse, the occurrence of shoulder dislocation was actually lower in college-aged than in high school-aged athletes. This finding can likely be explained by the fact that there are significantly more high school athletes (7,937,491) than collegiate athletes (499,217) nationwide.^{1,7} In addition, however, this may be attributable to the uniquely competitive nature of collegiate athletics, which require an elite level of skill, experience, fitness, and muscle conditioning that in turn confer a lower risk of injury.

While previous studies^{4,9,14} have reported higher rates of shoulder dislocation among sports with high levels of physical person-to-person contact (ie, football, ice hockey, soccer, wrestling, lacrosse), our findings indicate this may not be entirely valid. In examining the fifteen sports with the highest overall rates of dislocation in the present study, only seven represented “full-contact” sports (football, soccer, ice hockey, wrestling, boxing, hockey, lacrosse). For the “non-contact” sports, it has been hypothesized that sports with high kinetic energy-generation and those that require constant repetitive movements (ie, blocking a shot in basketball, overhead strokes in swimming, and so on) may cause a disruption in the kinetic chain with an accompanying increase in capsular laxity and joint instability.⁴ This may predispose athletes to an increased likelihood of shoulder dislocations in the case of non-person-to-person traumatic events such as a fall on an

outstretched hand or an equipment-related injury. Alternatively, high rates of shoulder dislocation observed in noncontact sports may also occur from a collision with the playing surface.^{2,3} For example, Carr et al³ reported that dislocations in baseball occur during high rotational velocity and force generation across the shoulder while bat-swinging and more commonly with sliding/diving maneuvers during defensive plays. Although the exact cause of these noncontact injury trends were not elucidated in this study, we hypothesize that the increasingly competitive nature and energy demands of organized sports across both age groups, and the high contact nature of collision sports played a role in the high incidence of shoulder dislocations. Additional investigation of the observed contact vs. noncontact sport differences in shoulder dislocation and its potential driving force is needed.

This investigation has several limitations. While the NEISS database is a useful tool for estimating injury data and epidemiologic trends in the United States, it has a few inherent limitations. Because the provided totals are weighted estimates based on a probability sample of ED visits, the numerical estimates could be subject to sampling bias and may not represent the true incidence of injury in the given study population. However, NEISS does account for these inherent biases in their algorithmic model. In addition, because this database only represents patients who present to EDs, those who did not seek medical care or presented to another care location (primary-care office, specialists, and so on) are not accounted for. Similarly, it is plausible that highly competitive athletes may have sustained a dislocation during in-game athletic competition, were immediately treated by a health-care professional at the time of injury, and thus never presented to the ED. Finally, the database lacks traditional variables that are of interest in orthopedic care (ie, mechanism of injury, surgical intervention, long-term outcomes, and return to play data). While this may limit the generalizability in comparing high school–aged and college–aged athletic injury mechanisms, it is the first of its kind to attempt such a comparison for shoulder dislocations presenting to the emergency room. Therefore, the findings of this study have important implications for elucidating the sports-specific mechanisms of shoulder dislocations for high school–aged and college–aged athletic populations and provide initial data for informing sport-specific injury prevention and treatment methods.

Conclusion

High school–aged and college–aged athletes presenting to the ED with shoulder dislocations were disproportionately male athletes. Overall incidence of injury did not significantly differ between age groups. Sports with high levels of physical contact were more likely to cause shoulder dislocation in high school–aged athletes than college–aged athletes.

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